(12)

THIRD QUARTERLY PROGRESS REPORT

FOR

MANUFACTURING METHODS AND TECHNOLOGY (MMTE)

MEASURE FOR FABRICATION OF LOW VOLTAGE

START SEALED BEAM ARC LAMPS

1 December 1976 to 28 February 1977

CONTRACT NO. DAAB07-76-C-0034

U.S. Army Electronics Command
Production Division
Production Integration Branch
Ft. Monmouth. NJ 07703

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A xenon lamp optical and cooling assembly was designed and fabricated for adaptability in searchlight applications.

MANUFACTURING METHODS AND TECHNOLOGY (MMTE)

MEASURE FOR FABRICATION OF LOW VOLTAGE

START SEALED BEAM ARC LAMPS

THIRD QUARTERLY PROGRESS REPORT

1 December 1976 to 28 February 1977

"The objective of this manufacturing methods and technology project is to establish the technology and capability to fabricate Low Voltage Start Sealed Beam Arc Lamps".

CONTRACT NO. DAAB07-76-C- 0034

By

Edwin Chan
Roy Roberts
Tim Bell

ABSTRACT

A program is in progress to establish a production capability for the purpose of meeting estimated military needs for the X6335, a 1kW sealed beam xenon arc lamp with low voltage starting mechanism.

In accordance with the requirements of the contract, the second engineering sample was delivered.

The safety requirement to avoid damage from explosion or overpressure has been achieved in the fabrication of the depressurize plug. The rupture disc within the depressurize plug has met the blowout specifications to function above the normal operating pressure of the lamp and below the lamp's explosion point.

A xenon lamp optical and cooling assembly was designed and fabricated for testing the lamps.

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1.0 PURPOSE

The objective of this program is to establish a production capability for the purpose of meeting estimated military needs for a period of two (2) years after completion of the contract, and to establish a base and plans which may be used to meet expanded requirements.

The program is intended to demonstrate and to "prove-out" the manufacturing processes, methods and techniques that are utilized in the production of 1kW sealed beam xenon arc lamps with a low voltage starting mechanism.

The lamp initially chosen for the program was the X6257. This lamp has been produced for military searchlight applications. The high voltage version of this lamp was developed initially under Contract Number DAAK02-68-C-0215. The 1kW lamp was further refined on a PEM Contract Number DAAB05-71-C-2609. The low voltage starting X6257 was not developed with government funds, but was developed with EIMAC funds.

This contract is divided into three phases:

1. Engineering Samples, wherein modifications are being made to designs arrived at under previous development in order to improve their optical performance, safety and utility in the field and to reduce their cost. Production drawings, procedures, and tooling will also be developed. These parameters will be based on delivery of three (3) samples.
2. Confirmatory Samples, wherein the delivery of three (3) units will be made to demonstrate that lamps can be made with production techniques and procedures to meet the specification.

3. Pilot Run, wherein the delivery of thirty (30) units will be made to demonstrate the capability of meeting the planned production rate.

The Engineering Sample Phase is needed to incorporate features which will make the lamp start more reliably, be easier to fabricate, be safer to operate, have a highly accurate mounting surface for optical reference and afford cost reduction.

Problem areas anticipated are the following:

1. Bearing surfaces for movable stinger.
2. Accurate cathode tip location relative to the reflector focal point.
3. Starting reliability of the lamp.

During the second quarter the second engineering sample was delivered. During this quarter the final design for the depressurize plug and the optical mounting system has been completed.

The depressurize plug has been tested and evaluated by using the rupture disc conditions to validate the design parameters. The rupture disc physical characteristic functions above the normal operating pressure of the lamp and below the explosion point.

The optical mounting system has been fabricated and evaluated for application into a searchlight system.

2.0 GLOSSARY

LVS............................Low voltage starting

Stinger........................Moveable electrode used for lamp ignition

Reflector Mandrel..............A stainless steel tool which is polished to a mirrored surface with a precise elliptical contour upon which the reflector is electroformed.

EI (characteristic)............The voltage (E) across the lamp for a given current (1) passing through the lamp.

3.0 NARRATIVE AND DATA

The lamp is comprised of conventional tungsten electrodes positioned in a ceramic/metal structure with a reflector and sapphire window. The arc is located at the focal point of the reflector so that a directed beam is obtained coaxial with the electrodes. The low voltage starting mechanism includes a moveable electrode called the "stinger" which is coaxial with the anode.

The lamp is filled with up to 20 atmospheres of high purity xenon at room temperature. The lamp's spectral output is a typical high pressure xenon arc spectrum as reflected from a silver mirror and transmitted through a sapphire window; the wavelength range is about 130nm to 6500nm. The silver reflector coating was selected for maximum output in the visible and near IR bands.

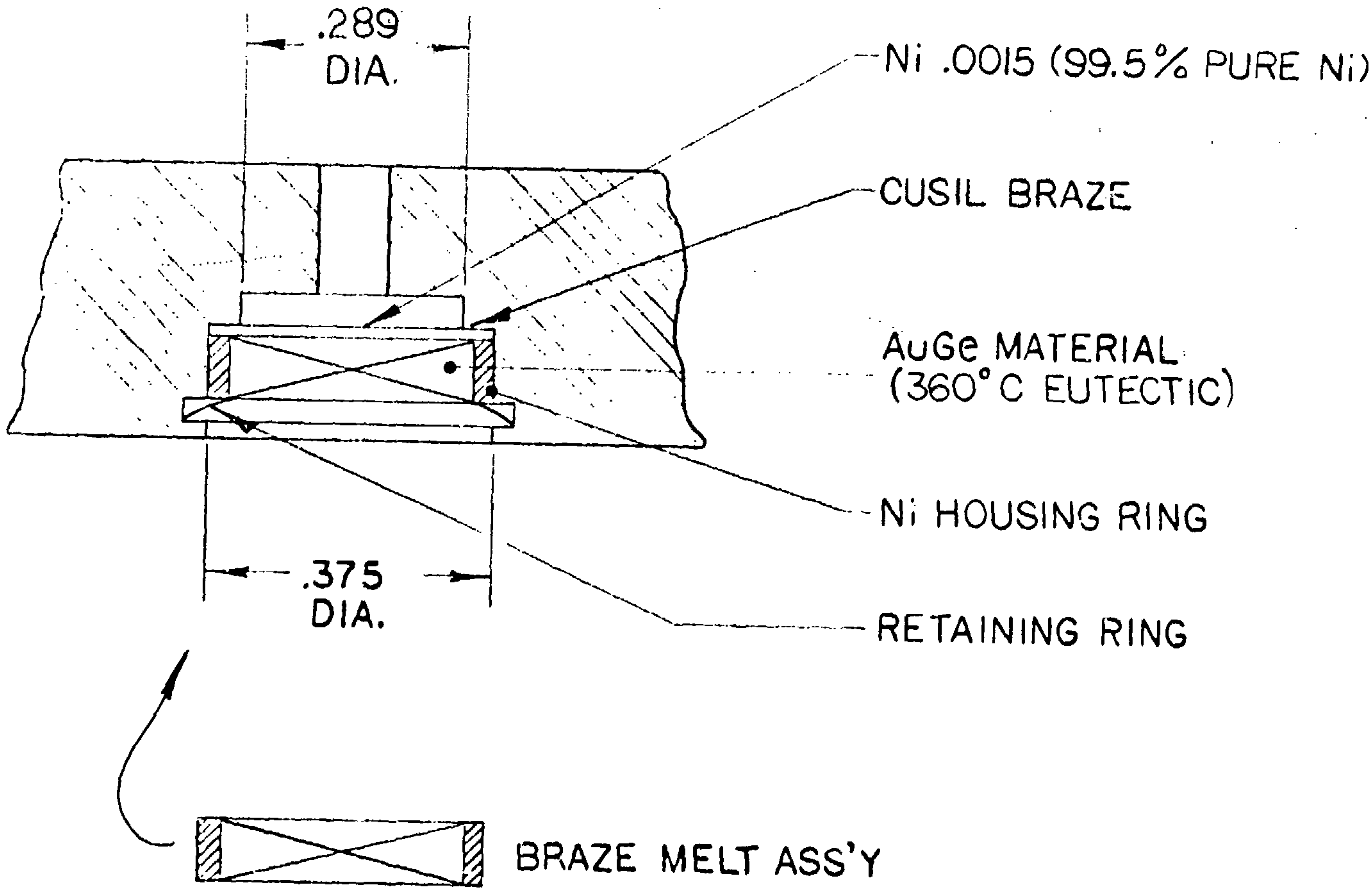
The lamp operating voltage is 19 volts D.C. $\pm$ 10%. The lamp voltage is determined primarily by the interelectrode gap and the lamp pressure. The lamp acts much like a constant voltage device, that is, large changes in current result in small changes in operating voltage. Ignition is accomplished by use of the stinger. To commence the start cycle, the solenoid voltage is applied causing the stinger to move forward. The moment the stinger contacts the cathode tip, the electrical circuit is completed and current begins to flow through the choke. After approximately 1 second, the solenoid voltage is removed and the stinger starts to return to its deenergized position, thus breaking the circuit. At this time, the stored energy in the choke is dumped into the arc. The stinger then draws this arc back and transfers the arc to the anode.

3.0 NARRATIVE AND DATA/CONTINUED

The requirement to safely depressurize the lamp and avoid damage or explosion from overpressure has been achieved in the design and fabrication of the depressurize plug. Figure 1 is the view of the depressurize plug. Additionally, the rupture disc for the depressurize plug was fabricated, tested, and evaluated to meet the internal pressure stresses for the safety requirement. Figures 2 and 3 show the present configuration of the pressure disc. Also, the mounting system has been fabricated and evaluated and is a specially designed holder that will be used for testing the lamps.

3.1 DESIGN AND ANALYSIS

The requirement to safely depressurize the lamp before an overpressure condition could cause an explosion required that certain conditions and design features to be merged. The depressurize plug must sustain operating conditions of the lamp. Therefore, the blow-out feature must be designed to withstand bakeout temperatures and full vacuum conditions and still rupture within the range of 360°C at 560 psi. To achieve these requirements a .0015 inch thick nickel disc was designed to blow-out at 425 psi at 360°C without a braze back-up. This rupture disc sustained itself under bakeout and full vacuum without a braze back-up. A gold germanium material eutectic at 360°C was tested as the braze back-up material. This material was inserted into a counterbore housing immediately following bakeout and prior to xenon filling at 250 psi. A bowed snap ring will pre-load the gold germanium brazed assembly during lamp operation. As temperature increases the eutectic gold germanium back-up will liquify at 360°C and no longer provide for a braze back-up. Internal pressure at this point



Configuration of present Design
Depressurize Plug

Figure 1

is 560 approximately and the depressurize plug will rupture.

3.1.1 Mounting System

The mounting system as shown in Figures 4 through 7 has been designed and fabricated. It is a specially designed holder that will be used in testing lamps. The mounting system is composed of a six inch aluminum tube with coaxial contacts for the anode, cathode and stinger. Also integral is the solenoid coil and plenum chamber with the inlet air duct. All contact rings are full floating with a removeable lamp window indexing fixture.

3.2 FABRICATION

The first, second and third lamps of the Third Engineering Sample phase were fabricated and in the process of being tested. The test vehicles shown in Figure 3 for the rupture disc were fabricated, tested and evaluated.

3.3 TESTING

The requirement to design and provide a means to safely depressurize the lamp have been achieved. The conditions and design features are provided as follows:

1. Operating conditions of the lamp are 200°C maximum at 450 psi.
2. Design conditions for the depressurize plug:
   - A. Burst pressure of 560 psi at 360°C.
   - B. Must sustain bakeout temperature of 500°C at full vacuum.

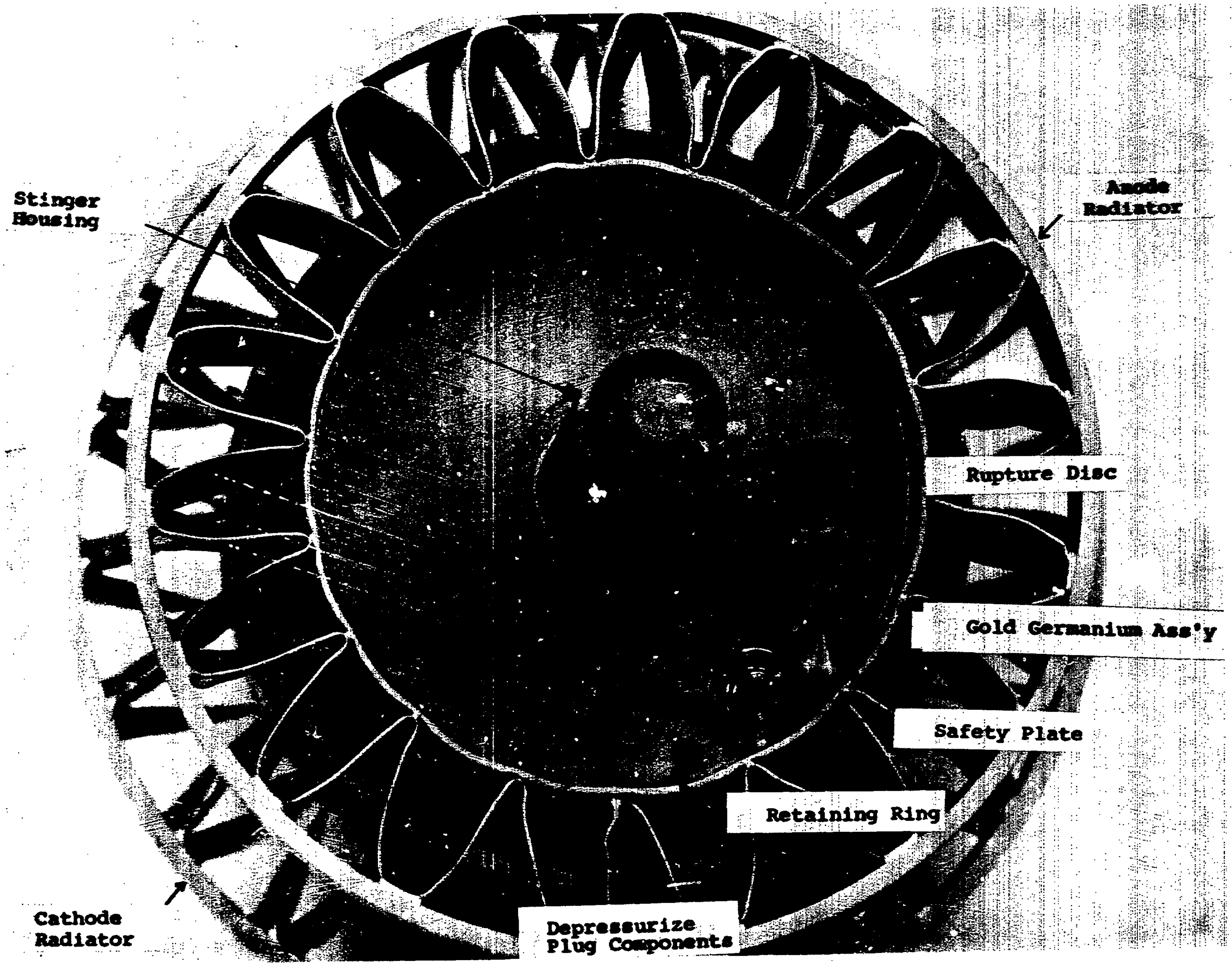
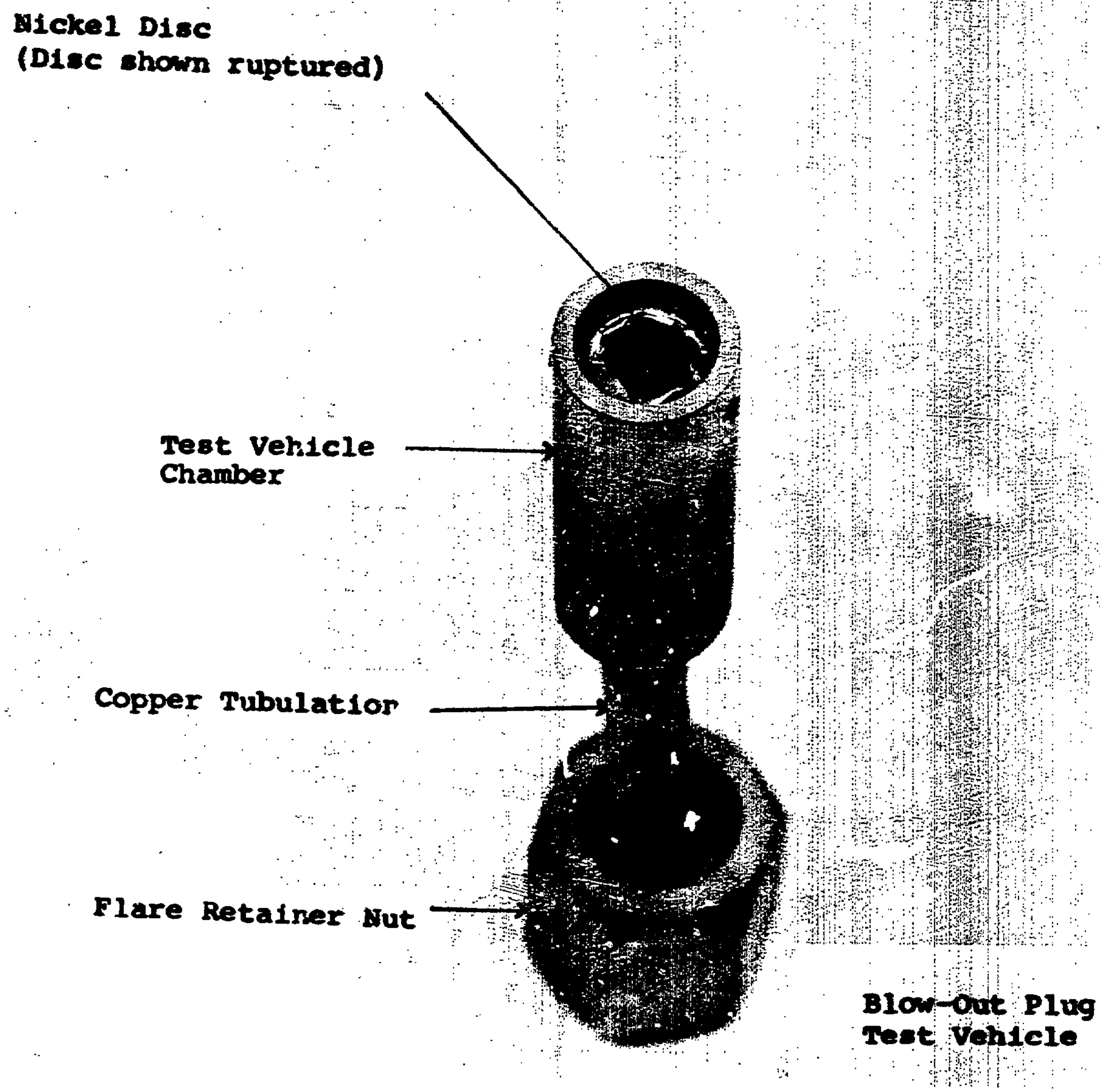
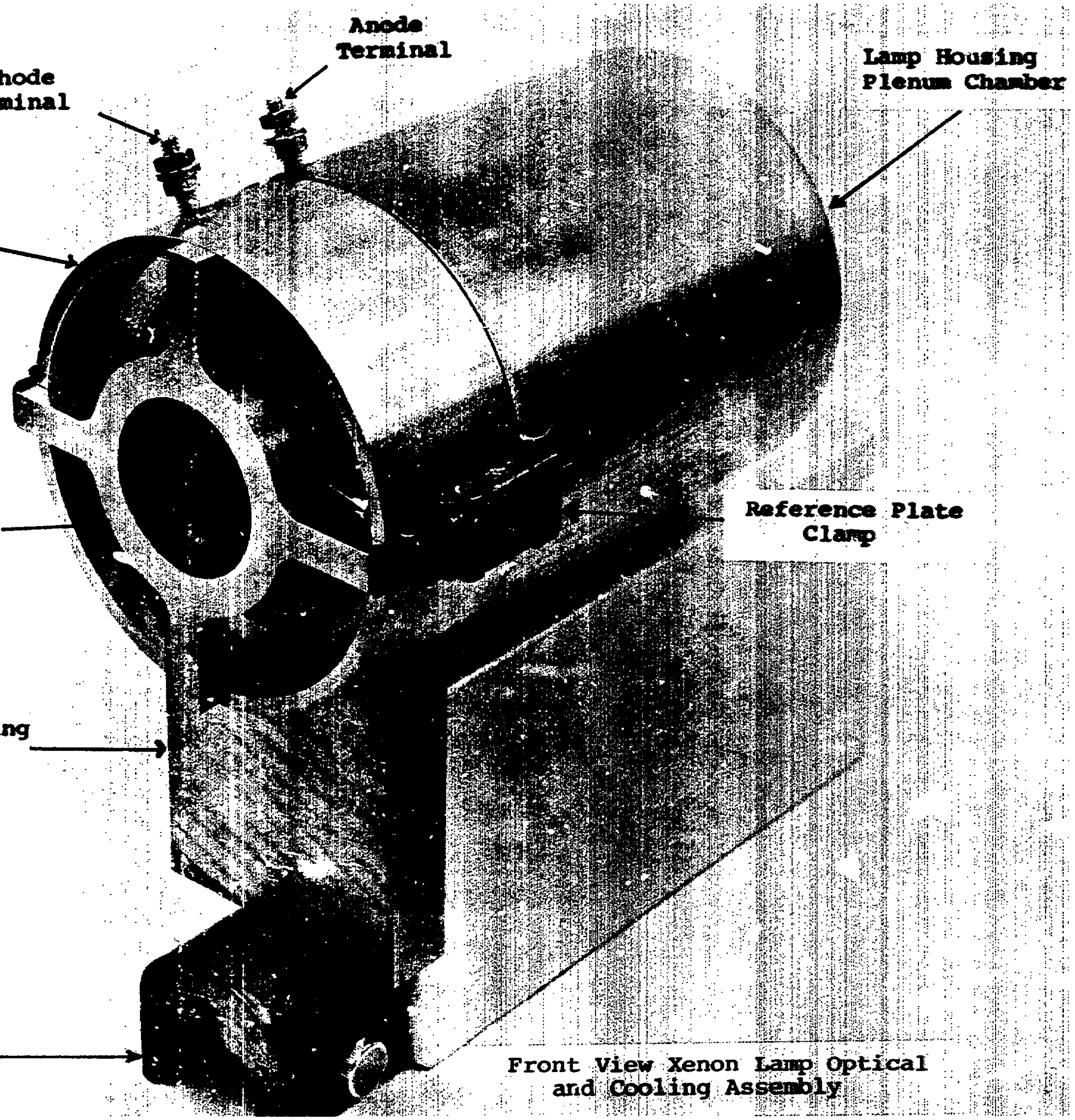

Stinger
Housing
Anode
Radiator
Rupture Disc
Gold Germanium Ass'y
Safety Plate
Retaining Ring
Depressurize
Plug Components
Cathode
Radiator

Figure 2



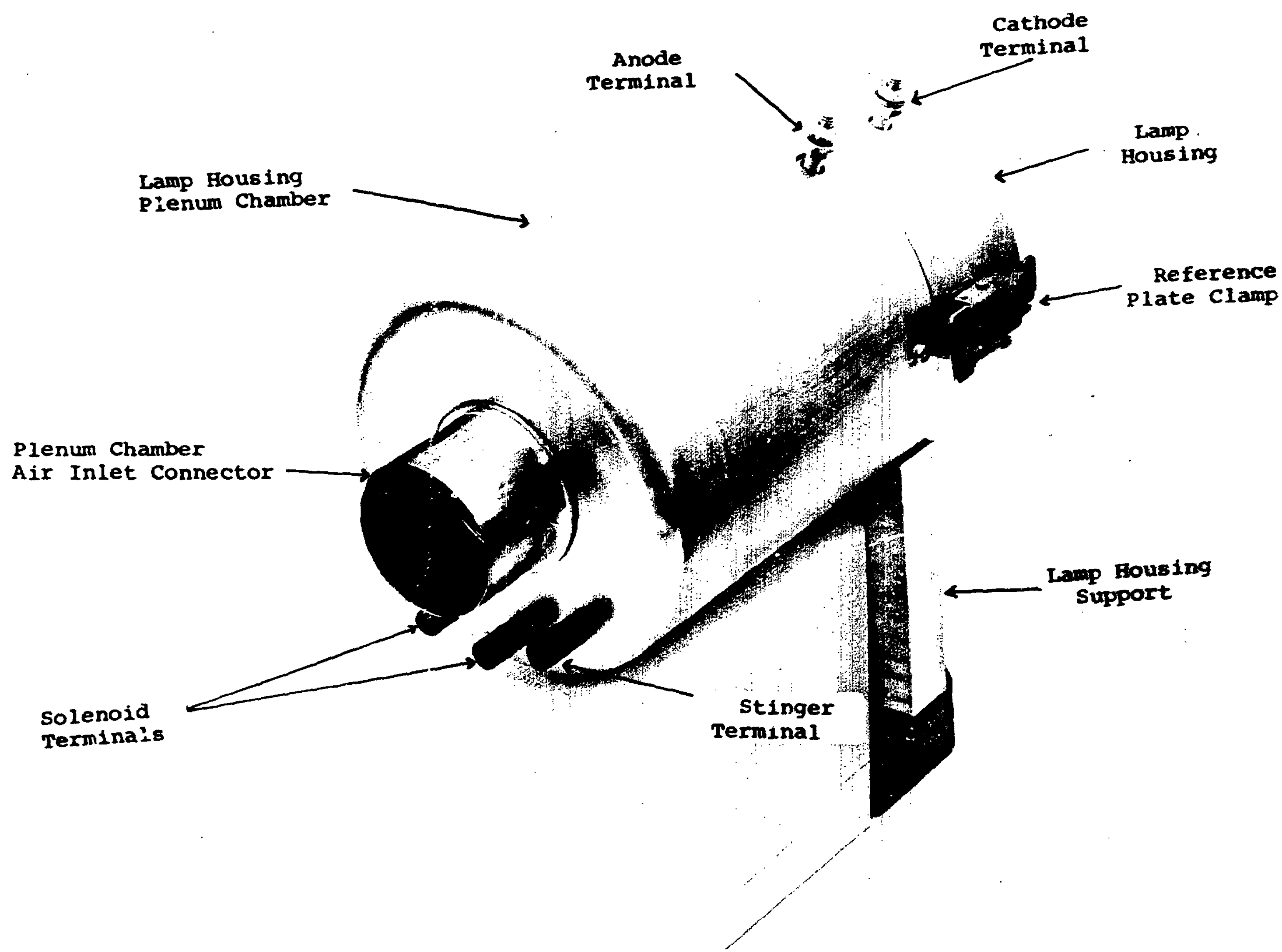
Blow-Out Plug
Test Vehicle

Figure 3



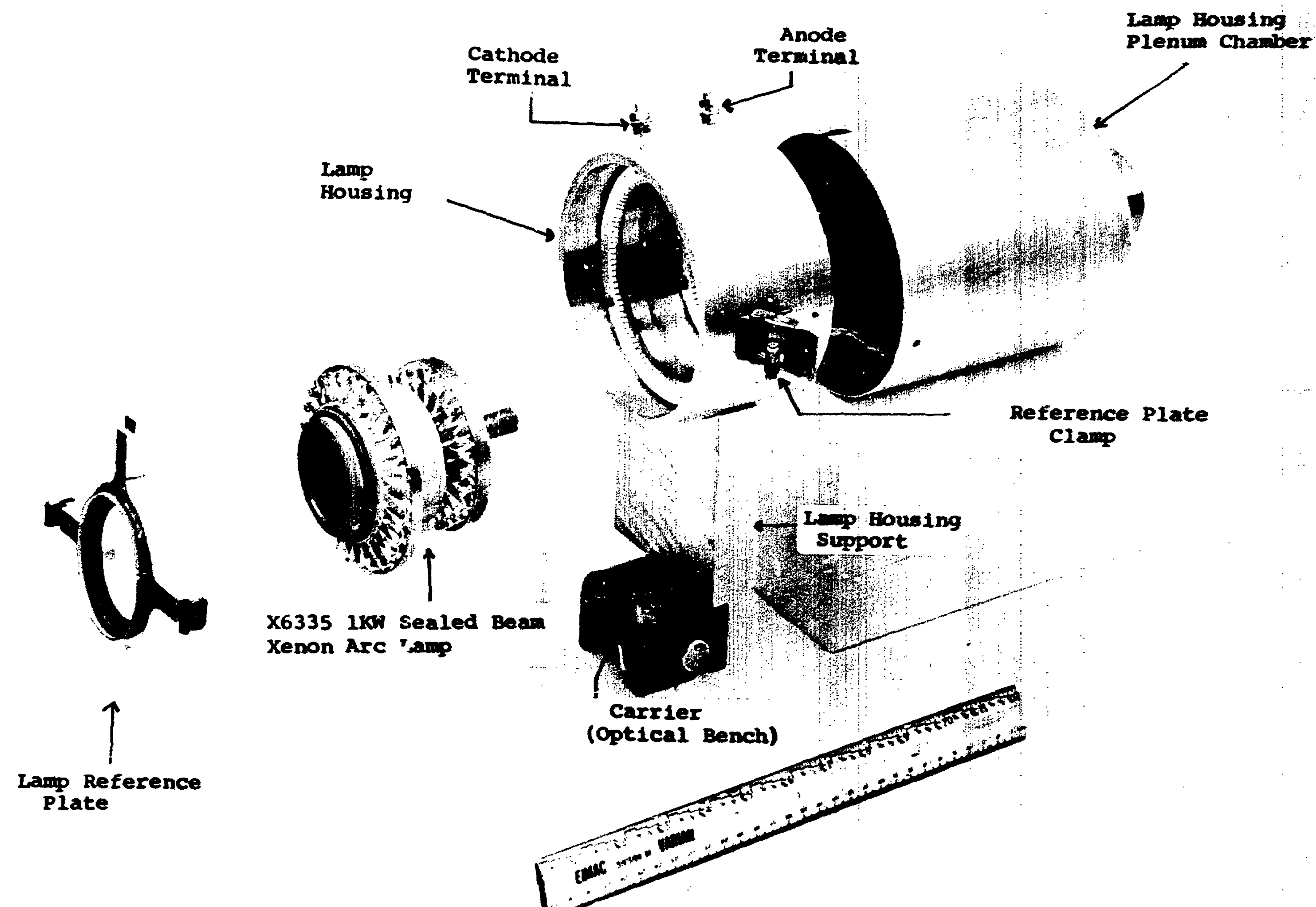
Front View Xenon Lamp Optical and Cooling Assembly

Figure 4



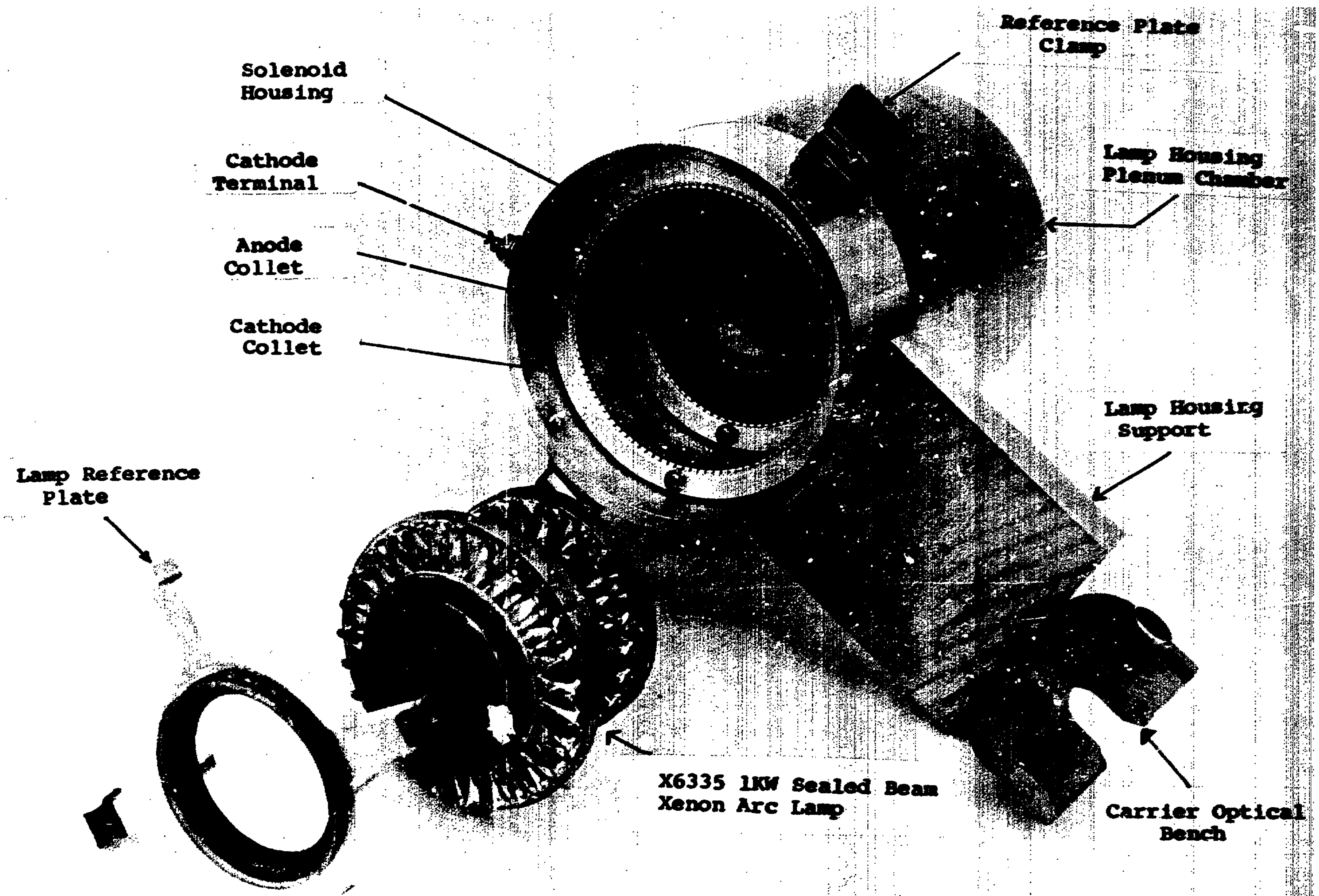
Back View Xenon Lamp Optical and Cooling Assembly

Figure 5



Exposed View Xenon Lamp Optical
and Cooling Assembly

Figure 6



Frontal Exposed View Xenon
Lamp Optical and Cooling Assy.

Figure 7

3. In order to satisfy the above conditions the following design features were tested and evaluated;

   A. A thin .0015 nickel disc has been evaluated to blow-out at 425 psi at 360° without a braze back-up.
   B. The rupture disc will sustain bakeout and full vacuum without braze back-up.
   C. A gold germanium material eutectic at 360°C was tested as a braze back-up material. This material was inserted into a counterbore housing immediately following bakeout and prior to xenon filling at 250 psi. A retaining ring will preload the gold germanium (AuGe) brazed assembly during lamp operation.
   D. As temperature increases (e.g. during fan outage) the eutectic gold germanium back-up will liquify (at 360°C) and no longer provide for a braze back-up. Internal pressure at this point is 560 psi approximately.
   E. Cross section area seeing load:
      For .289 diameter hole, subtract out fillet take up; therefore approximately .239 diameter would be approximately the area to resist pressure loading.
      As pressure increases the rupture disc being a thin and ductile material will assume an ellipsoidal shape. Therefore stress will be calculated for a thin ellipsoidal head.

      $$T = \frac{PD}{2S-.2P} = \frac{425(.239)}{2(34{,}000)-.2(425)} = .0015$$

      Use .0015 shim stock thickness with .289 diameter hole.

Where: P=Design pressure
S=tensile strength at ($360^{o}C$)
D=Diameter
T=Thickness

Four sample rupture discs were evaluated with the the following results:

Sample One:

The rupture disc was taken up to $360^{o}C$ at 570 psi and ruptured.

Sample Two:

The rupture disc was taken up to a fluctuating temperature and the pressure test of $200^{o}C$ at 450 psi (operating condition) then reducing the temperature and pressure to $50^{o}C$ at 250 psi. This procedure was performed for ten complete cycles without failure. A leak test was performed on test sample two and proved satisfactory. This same sample was taken up to $380^{o}C$ at 565 psi and ruptured

Sample Three:

This sample was taken up to 1800 psi ambient full capacity of air cylinder without failure. The sample was leak tested with helium and proved satisfactory. This same test sample was taken up to $370^{o}C$ at 570 psi and ruptured.

Sample Four:

Sample four was taken through 18 hours of bakeout at approximately full vacuum without the gold germanium braze backup. The temperature was held at $500^{o}C$. The sample passed the leak check test. The sample with the braze material installed was taken up to $370^{o}C$ at 570 psi and ruptured.

3.4 Conclusion

During this reporting period a safety device to depressurize the lamp was designed, fabricated and tested. This device is designed to release the xenon gas in the event the lamp temperature should reach 360°C. Several tests were performed using this safety device and in each case the temperature at which the lamp was depressurized was within ± 5% of the design goal of 360°C. The device was tested in test vehicles as well as in lamps. A lamp, optical and cooling assembly was also designed, fabricated and tested. This assembly is used for testing the lamp. The assembly can be mounted on an optical bench for the optical test.

4.0 Program for next interval

1. Test Third Engineering Sample.
2. Prepare Third Engineering Sample Test Report.
3. Deliver Third Engineering Sample and Test Report.
4. Order Parts and Material for Confirmatory Samples.
5. Prepare Tooling for Confirmatory Sample.
6. Distribute Third Quarterly Progress Report.

5.0 Publications and Reports

None

6.0 Identification of Personnel

The following is a list of the key personnel who worked on this contract during the period December 1976 through February 1977.

Ed Chan..................	148.0 Hours	
Gordon Liljegren..........	22.0 Hours	
Victor Kristen............	4.0 Hours	
Roy Roberts...............	52.0 Hours	
Charlie McGlew............	234.0 Hours	
Nick Picoulin.............	14.5 Hours	
Cheryl Handley............	4.5 Hours	(Draftsperson)
Greg Guild................	24.0 Hours	(Draftsperson)
Bob Fehringer.............	24.0 Hours	(Draftsperson)
Nick Cortese..............	33.5 Hours	(Technician)
Scott Flackman............	1.0 Hours	(Technician)
Lavaughn Overton..........	0.5 Hours	(Technician)
Anna Grotz................	1.0 Hours	(Technician)

Mr. Roy Roberts resume has been included in this report as being a new member of the EIMAC Illuminator Systems.

ROY D. ROBERTS

Roy Roberts recently joined the Illuminator Systems Division as a Development Engineer and is presently responsible for stress analysis calculations of metallurgical items for lamps in searchlight and audio-visual systems.

His past experience included designing piping systems, storage tanks, columns and vessels with Standard Oil of California. He specialized in statistics and stress analysis calculations. Additionally, he has extensive involvement with writing specifications for oil refinery equipment. His duties also included mechanical design with broad experience involving design layouts, final production drawings and product testing in kinematics.

Education:

Fresno State University	1971 B.S.	(Industrial Tech.)
California State University, Hayward	1968 A.A.	(Mathematics)
College of San Mateo	1966 A.A.	(Drafting Tech.)

Professional:

Member of the American Society of Mechanical Engineers.
Holder of several patents on kinematic products.

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